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Paper and board — Determination of water vapour transmission rate of sheet materials — Dynamic sweep and static gas methods

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National foreword

This British Standard is the UK implementation of ISO 9932:2021. It supersedes BS 7406:1991, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PAI/11, Methods of test for paper, board and pulps.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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INTERNATIONAL STANDARD

ISO 9932

Second edition
2021-03-01

Paper and board — Determination of water vapour transmission rate of sheet materials — Dynamic sweep and static gas methods

Papier et carton — Détermination du coefficient de transmission de la vapeur d'eau des matériaux en feuille — Méthode dynamique par balayage de gaz et méthode statique

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Contents

Page

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

This second edition cancels and replaces the first edition (ISO 9932:1990), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— update of the normative references;

— removal of footnotes listing instruments in Clauses 4 and 5;

— addition of a general statement of the precision.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The rate of water vapour penetration through a barrier is an important property in many applications, for example, in building and in packaging. ISO 2528 describes a dish method for the determination of the transmission rate and this method has wide acceptance. It does, however, have three disadvantages. Results take several days to obtain, it is not suitable for transmission rates less than 1 g/(m^2·d) and it is not recommended for materials thicker than 3 mm.

The methods described in this document can, depending on the material being tested, produce results in a matter of hours and are suitable for materials with transmission rates considerably less than 1 g/(m^2·d). Depending on the specific apparatus, they are also suitable for materials up to 38 mm thick.

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INTERNATIONAL STANDARD ISO 9932:2021

Paper and board — Determination of water vapour transmission rate of sheet materials — Dynamic sweep and static gas methods

1 Scope

This document describes general test methods for determining the water vapour transmission rate of sheet materials by means of a dynamic gas method or a static gas method. Depending on the method and specific apparatus employed, materials up to 38 mm thick and with water vapour transmission rates in the range from 0,05 g/(m²·d) to 65 g/(m²·d) can be tested. The basis of the function of the instrumental techniques is briefly described. Advice on calibration is given in Annex B.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 186:2002, *Paper and board — Sampling to determine average quality*

ISO 2528:2017, *Sheet materials — Determination of water vapour transmission rate (WVTR) — Gravimetric (dish) method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
water vapour transmission rate
mass of water vapour transmitted through unit area in unit time under specified conditions of temperature and humidity. It is expressed in grams per square metre per 24 h [g/(m²·d)]

3.2
dry side
side of the test cell which is exposed to low humidity

3.3
wet side
side of the test cell which is exposed to high humidity

4 Method A: Dynamic sweep gas method

4.1 Principle

The test piece is mounted between two chambers. One at a known relative humidity and the other swept by a dry gas. The amount of water vapour picked up by the dry gas stream is detected by an

4.2.4 Inert dry gas (as required by the specific apparatus to be used), for purging on the dry side.

NOTE The gas is normally desiccated air or dry nitrogen.

4.2.5 Sensor, with rapid response and high sensitivity capable of detecting levels in the moisture content of the sweep gas equivalent to 0,05 % relative humidity or less. The sensor may take a number of forms: an electrical resistance element, an electrolytic cell, or an infrared detector.

4.2.6 Means to convert the output from the sensor into a signal that can be used to calculate the amount of moisture passing through the test piece being tested in unit time.

4.2.7 Means of maintaining the test chamber and the sweep gas and the sensor at the required temperature.

NOTE The normal test temperature is either 23 °C ± 1 °C or 38 °C ± 1 °C, but other temperatures can be used.

4.2.8 Specimen of stated water vapour transmission rate supplied by the instrument manufacturer for standardization of the test cell.

5 Method B: Static gas method

5.1 Principle

The test piece is mounted in a cell containing an electrolytic element and the cell placed in a humidity cabinet at the required temperature and relative humidity. The water vapour penetrating the cell is electrolyzed and consequently the relative humidity within the cell remains very low (<1 %). After equilibrium, the electric current is a direct measure of the rate of electrolysis (according to Faraday's law of electrolysis) and the water vapour transmission rate.

5.2 Apparatus

5.2.1 Control box, containing

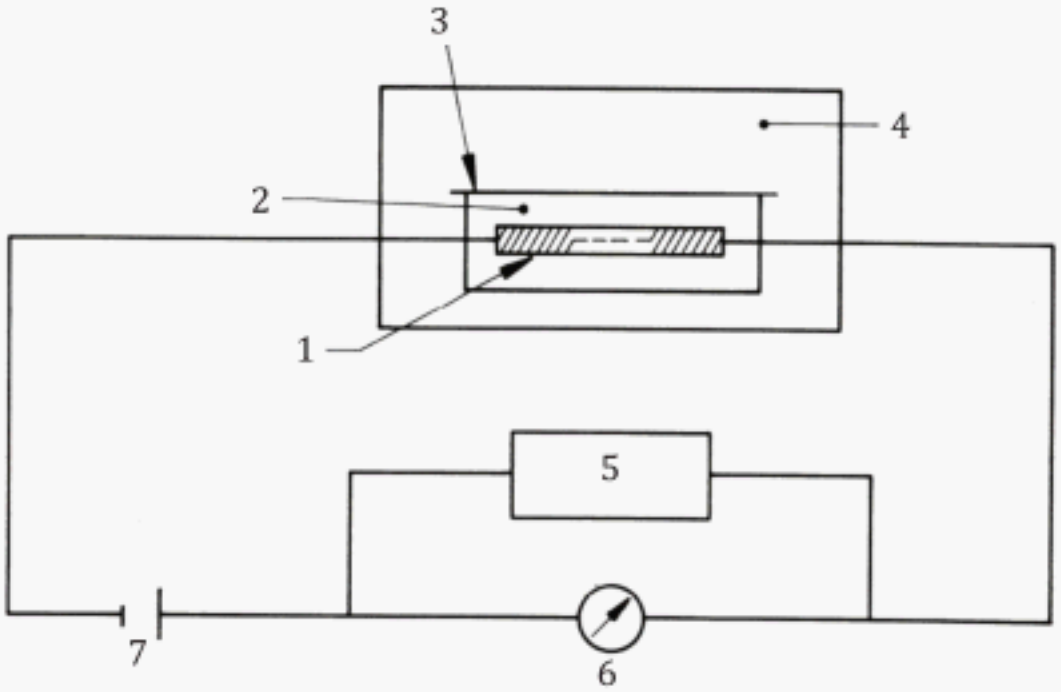
a) an electric power supply;

b) a microammeter, graduated directly in grams per square metre per 24 h [g/(m^2·d)];

c) selector and range switches;

d) connection points for cells and, if desired, a recorder.

See Figure 2.



Key

1 electrolytic element
2 dry side
3 test piece
4 enclosure maintained at required temperature and relative humidity
5 recorder
6 microammeter
7 power supply

Figure 2 — Schematic diagram of static system

5.2.2 Humidity cabinet, for storing the cells at the required conditions and having a fan for air circulation and small openings for entry of the plugs and cables of the cells. The required level of relative humidity may be obtained as prescribed in 4.2.3.

5.2.3 Stainless steel test cells, designed to clamp a defined area of a test piece and containing an electrolytic element which can be connected to the control box by means of a cable and plug.

5.2.4 Electrolytic element, consisting of two platinum wires wound at constant pitch round an inert former (glass and polytetrafluorethylene are suitable materials). A film of phosphorus pentoxide is deposited over the surface or the wires and former.

5.2.5 Means of drilling holes in test pieces.

5.2.6 Specimen of stated water vapour transmission rate.

6 Sampling

Select samples in accordance with ISO 186.

7 Preparation of test pieces

Test pieces shall be representative of the sample and shall take into account, where appropriate, variations within and between sheets and batches. The test area shall be free from faults likely to affect the determination.

The faces shall be designated one and two respectively. Where the two faces or the material can be distinguished, face one shall denote the face exposed to the wet side in service.

Carefully, in order to avoid damage to the test area, cut 10 test pieces to the required size and drill holes as necessary for the test cell being used.

Composite materials may have a core of permeable material which can provide a secondary path for moisture permeation if the edges are left exposed. In this case apply aluminium foil tape to the edges of such test pieces. The foil tape shall cover the edges and overlap the face by at least 10 mm. The foil tape shall be of the self-adhesive type, using dead soft tempered foil at least 40 µm thick.

Thick test pieces of homogenous construction may also allow moisture permeation through the edges and should also be treated as above.

NOTE No definitive statement can be given about the thickness at which sealing the edges becomes necessary, but as a general rule this should not be necessary for thicknesses less than 5 mm.

8 Procedure

The precise method to be used shall be obtained from the manufacturer's operation manual. The general procedure is as follows.

8.1 Method A

Fill the lower part of the test cell with water or the appropriate saturated saline solution containing a solid phase in order to obtain the required humidity and clamp the test piece in the cell with face one towards the wet side of the cell. Set the apparatus to the required temperature. Operate the apparatus in accordance with the manufacturer's instructions to obtain a reading, ensuring that a steady state has been reached. Record this reading and repeat the procedure for the remaining test pieces so that five readings are obtained with face one towards the wet side and five readings with face two towards the wet side.

8.2 Method B

Clamp the test piece in the cell with face one towards the wet side. Place the cell in the humidity cabinet at the required temperature and relative humidity. Record the rate of electrolysis of the water vapour passing into the cell as indicated by the microammeter until a steady state has been reached. Record the reading and repeat the procedure so that five readings are obtained with face one towards the wet side and five readings with face two towards the wet side.

8.3 Barrier material having one face of uncoated paper

Where one face of a barrier material consists of uncoated paper, and this face is towards the dry side, difficulties can be expected. All water must be removed from the paper by the dry gas before a constant water vapour transmission rate is indicated on the meter or recorder.

The pre-conditioning can last several days and care should be taken to ensure that a true steady state has been reached. It is recommended that the test be carried out only with the paper towards the wet side.

Where a water vapour transmission rate determination yields a value grossly different from comparable samples of the same material, the execution of the particular determination is suspect and shall be investigated and, if necessary, repeated.

8.4 Creased material

For some purposes it may be necessary to determine the transmission rate of creased material; in such cases carry out the creasing procedure described in ISO 2528:2017, Annex A and then follow the procedure of method A or method B as appropriate.

9 Expression of results

Calculate the mean and standard deviation of the separate determinations carried out with face one and face two facing the wet side respectively.

Express the results in grams per square metre per 24 h [g/(m^2·d)] for each side, tested to two significant figures.

10 Precision

10.1 General statement of the precision

There is scepticism that a proper seal can be done for paperboard and some nonwovens. There is also a lack of good repeatability data for these two types.

10.2 Method A

No firm statement about precision can be made at the time of publication. But work in the USA using similar principles gave a repeatability within the range from 2 % to 8 % of the test value and a reproducibility within the range from 7 % to 13 % of the test value based on samples within the range from 2,3 g/(m^2·d) to 24 g/(m^2·d) when tested at 38 °C and 90 % relative humidity.

10.3 Method B

There is no precise information for this method at the time of publication. According to the experience in the Netherlands, a repeatability of about 5 % of the test value and a reproducibility of 10 % to 15 % of the test value can be expected from materials with WVTR in the range from 2 g/(m^2·d) to 5 g/(m^2·d).

11 Test report

The test report shall include the following:

a) reference to this document, i.e. ISO 9932:2021;

b) the date and place of testing;

c) all information necessary for the complete identification of the sample;

d) the type of apparatus and the type of dry gas used;

e) the temperature and relative humidity used as the test conditions;

f) the arithmetic mean of the result for each face tested;

g) the standard deviation for each face tested;

h) if necessary, the results after creasing;

i) any deviation from the procedure specified.

Annex A
(normative)

Saturated saline solutions

A convenient means of obtaining a specified relative humidity is to make use of a saturated saline solution. A wide range of relative humidities is obtainable by the use of such solutions.

Table A.1 indicates those believed to be those most likely required by users of this document.

Table A.1 — Relative humidities

Salt	Relative humidity %	Temperature range °C
Magnesium chloride hexahydrate ($MgCl_2 \cdot 6H_2O$)	33 ± 2	10 to 70
Sodium chromate dihydrate ($Na_2Cr_2O_7 \cdot 2H_2O$)	52 ± 2	20
Sodium chloride (NaCl)	75 ± 2	10 to 100
Zinc sulphate heptahydrate ($ZnSO_4 \cdot 7H_2O$)	90 ± 2	20 to 25
Sodium tartrate dihydrate ($Na_2C_4H_4O_6 \cdot 2H_2O$)	91 ± 2	20 to 40

Annex B
(normative)

Calibration

B.1 General

No specific calibration instructions can be given in a general standard such as this, and users of this document are therefore recommended to refer to the manufacturer's instruction manual. A film material of known WVTR is normally supplied with the instrument and its use as required is sufficient to check for correct functioning of the apparatus.

Common sources of error are air leaks, residual moisture in the sweep gas, damage to the "standard" test film and, in the case of electrolytic cells, erosion of the phosphorus pentoxide coating.

In any event the source of the problem must be found, and the appropriate remedial action taken.

B.2 Gravimetric calibration of the instrument and standard test film

It may on occasions be necessary to check the calibration of the instrument, if for example, leakage or damage is suspected, or it may be decided to substitute a different test film as the standard. In such cases the following procedure may be adopted.

B.2.1 Add the saturated saline solution necessary to give the required humidity to the test cell (or humidity cabinet for apparatus appropriate to method B) and fix the test film in position. Run the apparatus in accordance with the manufacturer's instructions until steady conditions are obtained. Fix a charged and weighed Schwarz tube (or other equivalent absorber) to the outlet of the test cell followed by a charged calcium chloride tube to prevent absorption of water vapour from the atmosphere outside the test cell. Run the apparatus in accordance with the manufacturer's instructions until sufficient water has been absorbed in the Schwarz tube to obtain a reliable mass, at least 100 mg. Record the time taken to achieve this and weigh the Schwarz tube accurately to obtain the increase in mass. From the determination, calculate the mass of water vapour absorbed per hour and call this m_1.

B.2.2 Substitute an impermeable material such as polytetrafluoroethylene coated aluminium foil (aluminium face to the wet side) for the test film and repeat the procedure described in B.2.1 but allow the apparatus to run for at least 48 h. Calculate the mass of water vapour absorbed per hour and call this m_2.

NOTE m_2 originates from leaks in the system or incomplete drying of the sweep gas.

B.2.3 Calculate the WVTR of the test film as follows:

$$WVTR = \frac{24(m_1 - m_2)}{A}$$

where

m_1 is the mass of water vapour absorbed per hour according to B.2.1;

m_2 is the mass of water vapour absorbed per hour according to B.2.2;

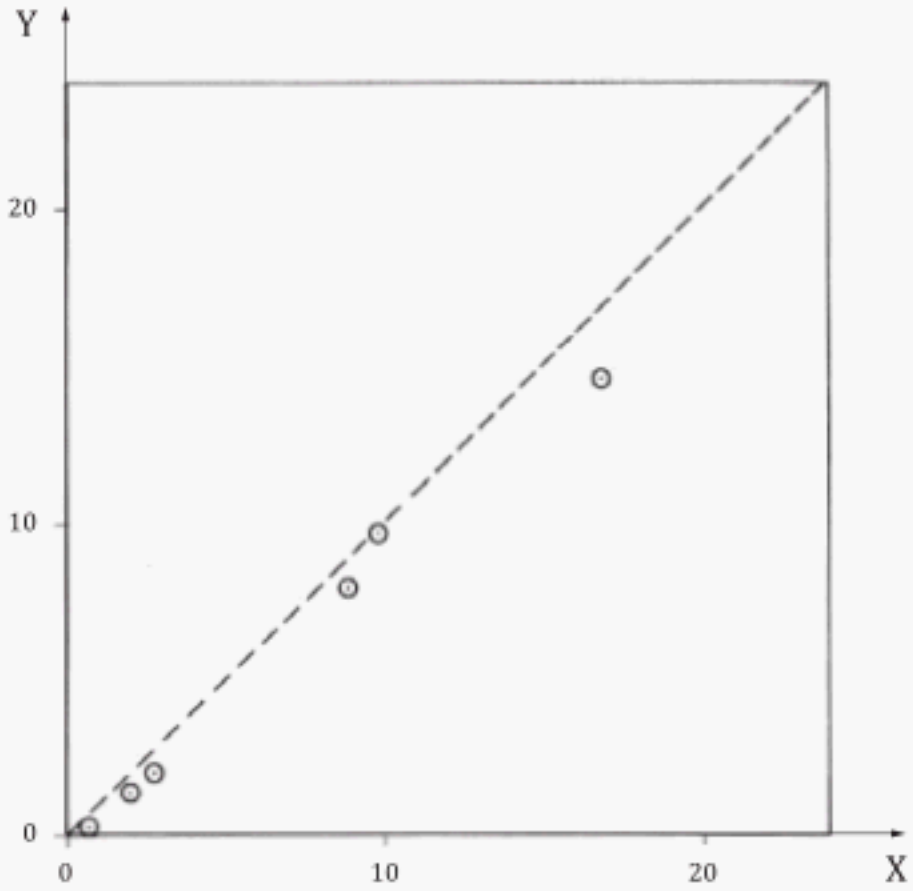
A is the exposed surface area of the test film in square metres.

Annex C
(informative)

Comparison of dynamic method with gravimetric method

A limited series of tests involving materials with WVTR in the range from 1 g/(m²·d) to 20 g/(m²·d) showed the dynamic method (method A) to give results which were comparable but lower than those obtained by the gravimetric method (ISO 2528). These results are illustrated by Figure C.1.

There is no known information on the comparison of the dynamic method with the static gas method.



Key

X gravimetric WVTR [g/(m²·d)]

Y dynamic WVTR [g/(m²·d)]

Figure C.1 — Dynamic method compared with gravimetric method

Bibliography

[1] ISO 187:1990, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

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